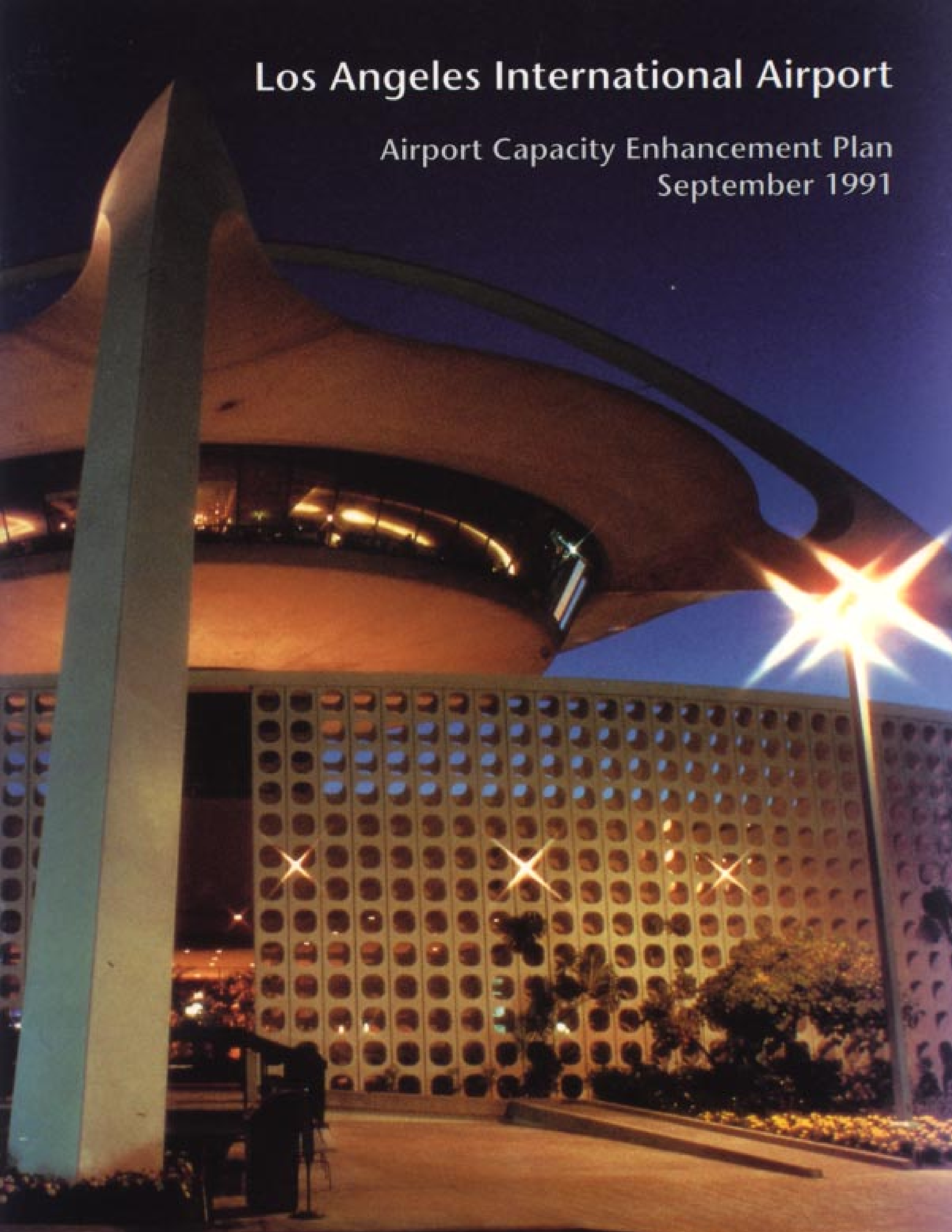
Los Angeles International Airport

Airport Capacity Enhancement Plan
September 1991



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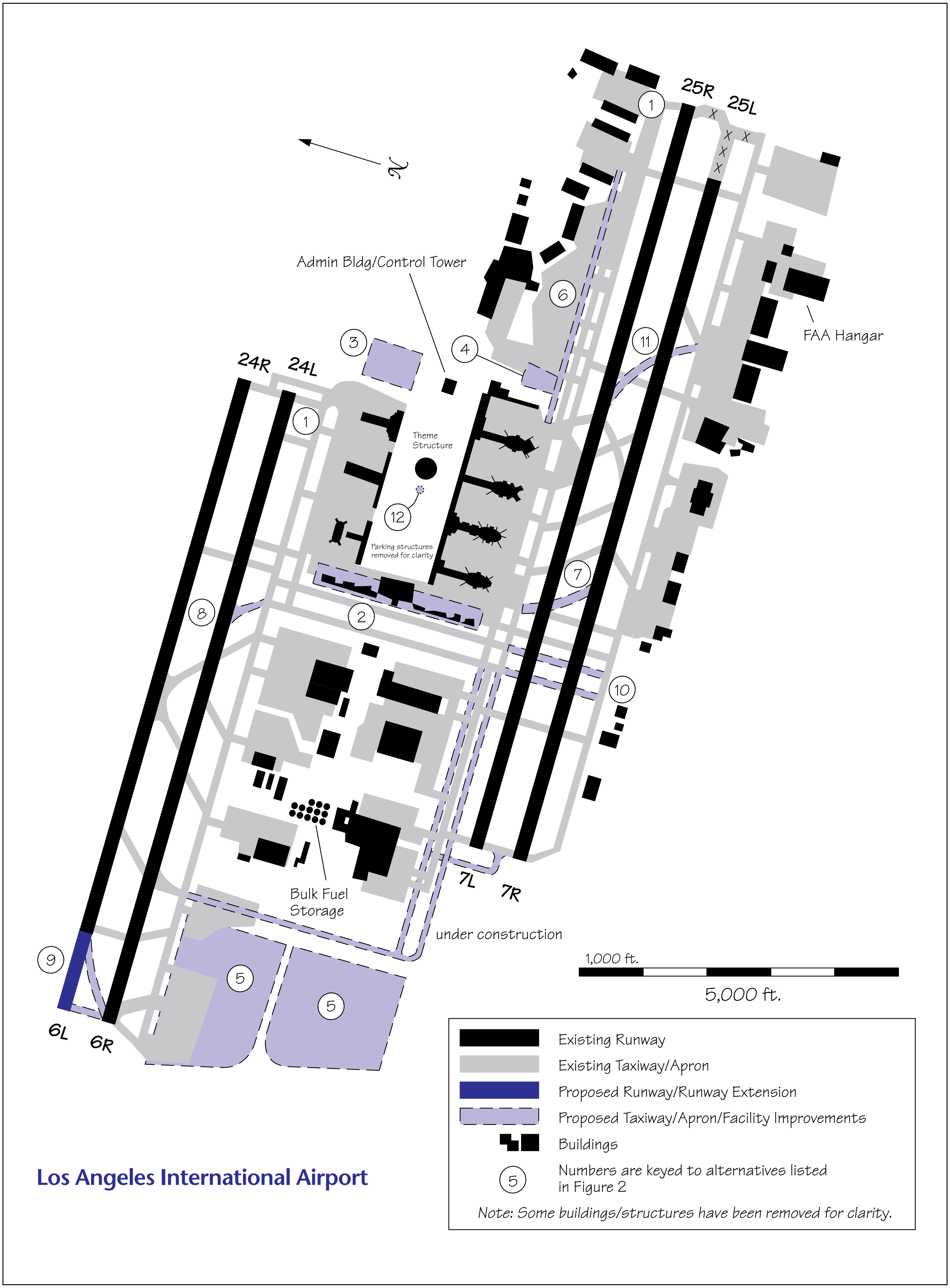
Prepared jointly by the U.S. Department of Transportation, Federal Aviation Administration, the City of Los Angeles Department of Airports, and the airlines and general aviation serving Los Angeles

Figure 1 Los Angeles International Airport



Los Angeles International Airport

Summary

The Federal Aviation Administration (FAA), airport operators, and aviation industry groups have initiated Airport Capacity Design Teams at various major air carrier airports throughout the United States to identify and evaluate alternative means to enhance existing airport and airspace capacity to handle future demand. A Capacity Team for Los Angeles International Airport (LAX) was formed in 1990.

Steady growth at LAX has kept it one of the busiest airports in the country and in the world. Activity at the airport has increased from 18,791,364 passenger enplanements in 1985 to 23,001,205 in 1990, a 22 percent increase. In 1990, the airport handled 679,861 aircraft operations (take-offs and landings). These traffic volumes placed the airport fourth in operations and third in passenger enplanements among U.S. airports and in the world. LAX is also ranked fourth in total air cargo volume in the world and second in the U.S.

The primary objective of the Capacity Team at LAX was to identify and assess various actions which, if implemented, would increase LAX's capacity, improve operational efficiency, and reduce aircraft delays. The purpose of the process was to determine the technical merits of each alternative action and its impact on capacity. Additional studies will be needed to assess environmental, socioeconomic, or political issues associated with these actions.

Some alternatives identified by the Capacity Team were tested using computer models developed by the FAA to quantify the benefits provided, while others were qualitatively evaluated. Different levels of activity were chosen to represent growth in aircraft operations in order to compare the merits of each action. These annual activity levels are referred to throughout this report as:

Baseline – 641,751 operations;
Future 1 – 711,092 operations;
Future 2 – 782,056 operations.

The Future 1 level of operations corresponds to a passenger level of about 56.5 million annual passengers, and Future 2, about 65 million annual passengers.

If no improvements are made at LAX (the "Do Nothing" scenario), the annual hours of aircraft delay will increase from 41,000 hours at the Baseline level of operations to 201,000 by Future 2. It should be noted that the implementation of all the recommended improvements will not eliminate delay. In fact, with all improvemnts, annual delay will still increase from the baseline level of 41,000 hours to 109,000 hours in Future 2. It is therefore imperative that other airports be developed within the region to avoid severe constraints on air traffic growth.

The major recommendations resulting from the Los Angeles study include:

- Construct departure pads (staging areas) at ends of runways.
- Construct 24 remote gates (no terminal) for domestic and international operations at west end.
- Extend Taxiway K to the east.
- Construct high-speed Taxiway 43.
- Extend Taxiways 48 and 49 to Taxiway F.
- Construct new air traffic control tower.
- Upgrade ILS on Runway 25L to CAT III.
- Taxi aircraft versus towing from remote parking areas to gates.

Figure 2 Capacity Enhancement Alternatives and Annual Delay Savings

	Alternatives	Action	Time Frame	Responsible Agency
Airfield Improvements				
1.	Construct departure pads (staging areas) at ends of runways.	Recommended	Baseline	DOA
2.	Construct new gates west side of Tom Bradley International Terminal (TBIT).	Study*	Future 2	DOA
3.	New domestic terminal east of Terminal 1.	Not Recommended	Future 2	DOA
4.	Construct 11-gate domestic terminal (east of Sepulveda) and 24-gate international terminal on the west end.	Study*	Future 2	DOA
5.	West end development.			
5a.	Construct 24 remote gates (no terminal) for domestic and international operations.	Recommended	Baseline	DOA
5b.	Construct 24-gate passenger terminal for domestic and/or international operations.	Study*	Future 2	DOA
6.	Extend Taxiway K to the east.	Recommended	Baseline	DOA
7.	Construct high-speed Taxiway 43.	Recommended	Baseline	DOA
8.	Construct high-speed Taxiway 49U.	Not Recommended	Baseline	DOA
9.	Extend Runway 24R and associated Taxiway 85V.	Not Recommended	Baseline	DOA
10.	Extend Taxiways 48 and 49 to Taxiway F.	Recommended	Baseline	DOA
11.	Construct high-speed taxiway off Runway 7L and 7R to cargo area.	Not Recommended	Baseline	DOA
Facilities and Equipment Improvements				
12.	Construct new air traffic control tower.	Recommended	Baseline	FAA
13.	Upgrade ILS on Runway 25L to CAT III.	Recommended	Baseline	FAA
Procedures Improvements				
14.	Taxi aircraft versus towing from remote parking areas to gates.	Recommended	Baseline	Airlines
15.	Restructure Los Angeles Basin airspace.	Study*	Baseline	FAA

* The term "Study" suggests either that a specific study be conducted or that it become part of a larger planning effort, such as a Master Plan update or a FAR Part 150 Airport Noise Compatibility Study. These proposals require further investigation at a level of detail that is beyond the scope of this effort.

Estimated Project Cost (in millions of 1990 dollars)	Estimated Annual Delay Savings[Δ] (in hours and millions of 1990 dollars) Baseline	Future 1	Future 2	
—	7,692/$14.06	30,701/$60.29	67,274/$141.23	(1)
$75.0	—	—	—	(2)
$120.0	—	—	(6,447/$13.53)	(3)
$425.0	—	—	2,297/4.82	(4)
				(5)
$36.3	—	—	1,722/$3.62	(5a)
$400.0	—	1,016/$2.0	8,846/18.57	(5b)
$27.0		†		(6)
$5.3	441/$0.8	444/$0.87	455/$0.96	(7)
$0.8		†		(8)
$3.9		†		(9)
$4.3		†		(10)
$5.4		†		(11)
$15.0		†		(12)
$1.3	1,053/$1.92‡	943/$1.85‡	619/$1.3‡	(13)
—	6,060/$11.08**	1,747/$3.43**	—	(14)
—	5,809/$10.62	13,839/$27.18	25,022/$52.53	(15)

Δ Cross-complex Taxiway 75 and Taxiways J and K are assumed to be available by Future 1.

† These improvements were not simulated. Therefore, no dollar figures are available. There is a description of each of these items in Section 2 — Capacity Enhancement Alternatives.

‡ Represents the delay savings based on 10 CAT III days per year, 3 hours per day. Delays decrease with time because of taxiway improvements (75 and J and K).

** Calculated with airfield improvements in place.

Figure 3 Flow Rate Versus Average Delay

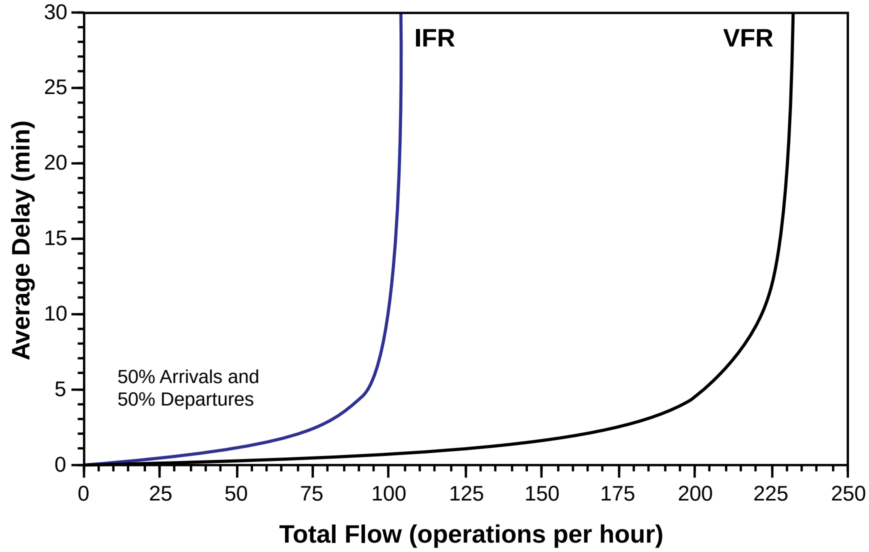


Figure 4 Profile of Daily Demand — Hourly Distribution

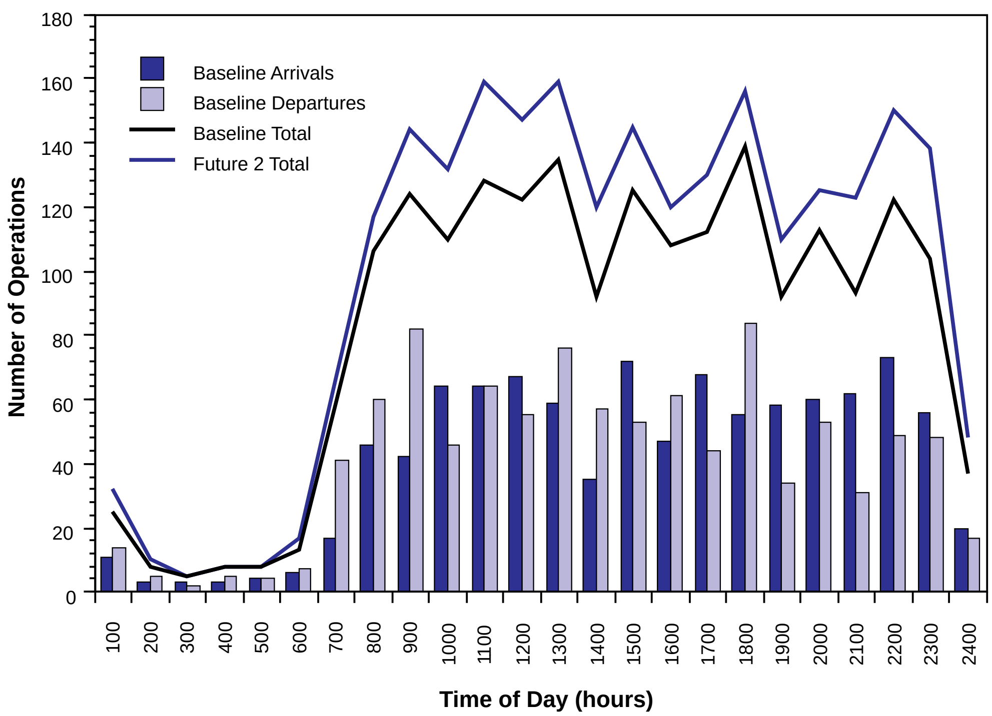


Figure 3 illustrates the flow rate versus average delay for LAX. The VFR curve represents the operation of the airfield under optimum FAA procedures. The IFR curve shows the capacity under instrument flight rules (IFR) which occurs during adverse weather conditions, only about 7.6% of the year. The actual current operating capacity of the airport is somewhere in between these two curves. The IFR curve indicates that aircraft delays will begin to escalate rapidly as hourly demand exceeds 90 to 100 operations per hour under IFR conditions. Figure 4 shows that hourly demand exceeds 90 to 100 operations during much of the day at Baseline demand levels and more so at Future 2. Therefore, substantial delays are likely during poor weather conditions. It is apparent that the current operating capacity is exceeded at the present time during peak hours based on observed delays.

Figure 5 Annual Delay Costs — Capacity Enhancement Alternatives

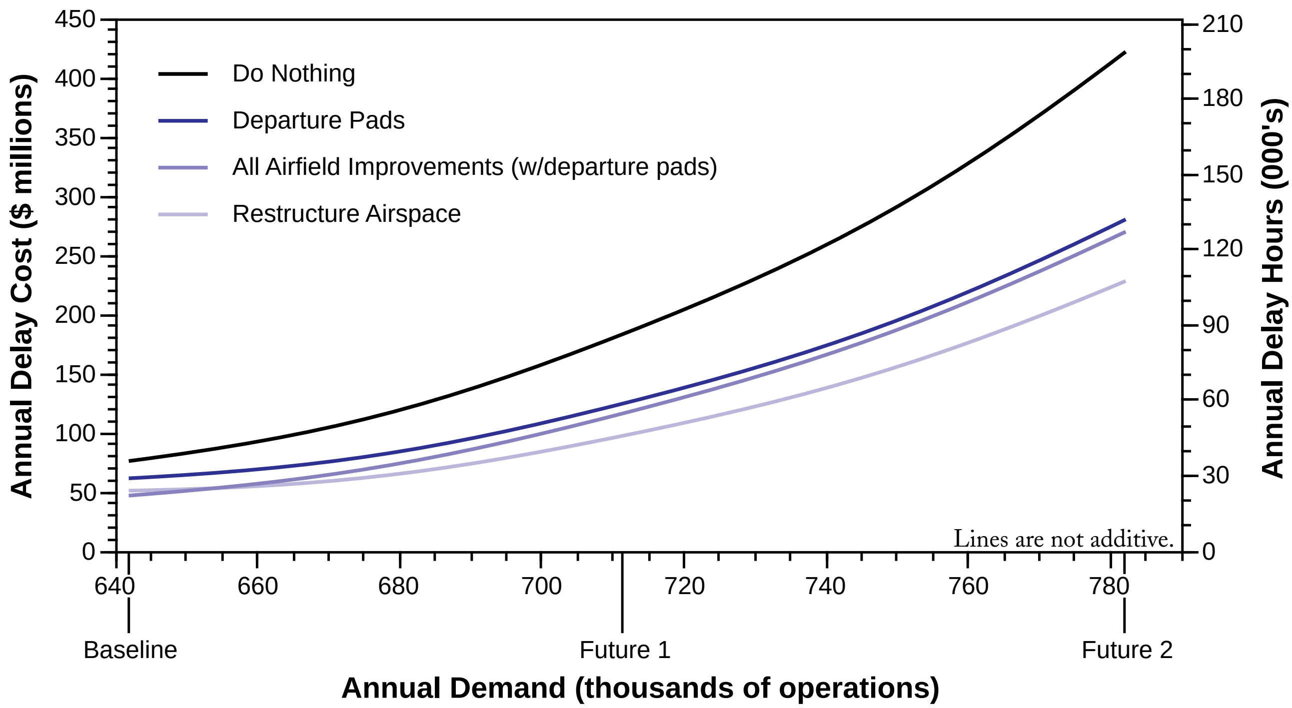


Figure 5 illustrates how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield capacity, i.e., the "Do Nothing" scenario. The graph shows that annual delay costs will increase from 41,492 hours or $75.83 million at the Baseline level of operations to 201,034 hours or $422.05 million by Future 2. The graphs also show that the greatest savings in delay costs would be provided by constructing departure pads (staging areas) at the ends of all the runways and restructuring terminal and Los Angeles Basin airspace.

Table of Contents

Section 1

Introduction

Background

Flight delays are often interrelated, in that problems at one airport are reflected throughout the airspace system and create delays and late flights at other airports. Figure 6 shows the airports projected to exceed 20,000 hours of annual aircraft delay by 1998, without airport and airspace improvements.

The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

To begin to meet this challenge, the FAA, along with airport operators and aviation industry groups throughout the country, have initiated joint industry and government airport Capacity Teams to study airport capacity enhancement at the major air carrier airports in the U.S. The objectives of these studies are to identify various alternatives for increasing capacity and to evaluate their potential to reduce delays.

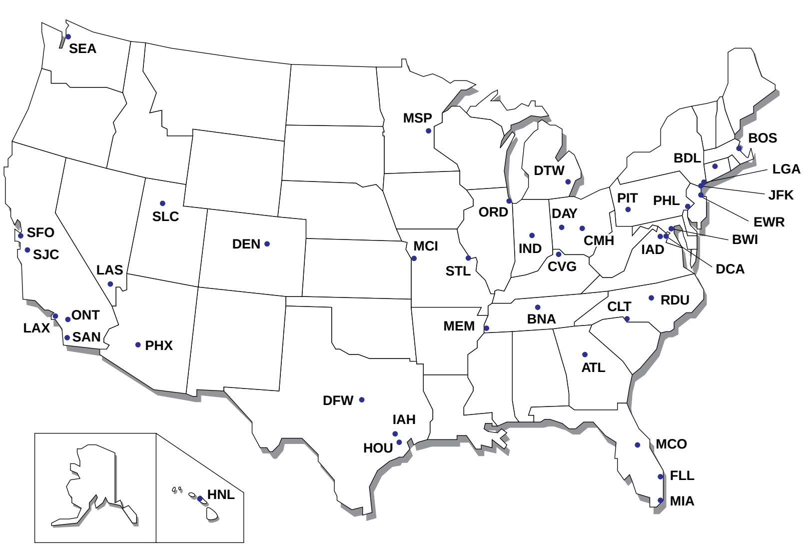
Over the past decade, steady growth at Los Angeles International Airport (LAX) has kept it one of the nation's busiest airports. Enplanements at LAX rose from 18,791,364 in 1985 to 23,001,205 in 1990, a 22 percent increase. LAX's total aircraft operations reached 679,861 in 1990, ranking it as the fourth busiest airport in the U.S and in the world. LAX is also ranked second in total air cargo volume in the U.S. and fourth in the world.

This report has established benchmarks for development based upon air traffic levels and not upon any definitive time schedule, since growth parameters can vary from projections. As a result, the report should retain its validity until the highest traffic level is attained regardless of the actual dates paralleling the development.

A "Baseline" benchmark was established based on a projected 1990 annual traffic level of 641,751 aircraft operations (takeoffs and landings). Two future traffic levels, Future 1 and Future 2, were established at 711,092 and 782,056 annual aircraft operations respectively, based on Capacity Team consensus of potential traffic growth at Los Angeles. The Future 1 level of operations corresponds to a passenger level of about 56.5 million annual passengers, and Future 2, about 65 million annual passengers. If no improvements are made at LAX, annual delay levels and delay costs are expected to increase from an estimated 41,400 hours and $75.83 million at the Baseline activity level to 201,000 hours and $422.05 million by the Future 2 demand level.

The improvements evaluated as a part of the Capacity Team's efforts are delineated in Figure 2 and described in some detail in Section 2 — Capacity Enhancement Alternatives.

Figure 6 Forecast of Airports Exceeding 20,000 Hours of Annual Aircraft Delay in 1998



Source: FAA Office of Policy and Plans

Objectives

The major goal of the Capacity Team at LAX was to develop an action plan of alternatives to increase airport capacity, improve airport efficiency, and reduce aircraft delays. In achieving this objective, the Capacity Team:

- Assessed the current airport capacity and the causes of delay associated with airspace, airfield, apron, and gate-area operations.
- Identified and evaluated capacity and delay-reduction benefits of alternative improvements.
- Examined the relationship between air traffic demand and delay, so that it could be used as an aid in establishing acceptable air traffic movement levels.

Scope

The Los Angeles International Airport Capacity Team limited its analysis to aircraft activity within the terminal area airspace and on the airfield. The analysis focused on means for increasing facility operating efficiency and reducing delays through procedural adjustments, airport development actions, or airport use and operating policy changes. The Capacity Team considered the technical and operational feasibility of the proposed improvements, but did not address environmental, socioeconomic, or political issues regarding airport development. While environmental implications were recognized in the development of some recommendations, the precise assessment of environmental impact was outside the scope of the Capacity Team. These issues need to be addressed in future airport system planning studies, and the data generated by the Capacity Team can be used in such studies.

Methodology

The Capacity Team proceeded along a logical sequence of events, with periodic meetings for review and coordination. The FAA Technical Center's Aviation Capacity Branch provided technical support and expertise in airport simulation modeling. Other Capacity Team members contributed suggested improvement alternatives, data, text, and capital cost estimates.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at LAX. Proposed improvements were analyzed in relation to current and future demands with the help of two computer models, the Airfield Delay Simulation Model (ADSIM) and the Runway Delay Simulation Model (RDSIM). Appendix B briefly explains the two models.

The simulation models considered air traffic control procedures, airfield improvements, and traffic demands. Air traffic control procedures and system improvements determined the aircraft separations to be used for the simulations under both VFR and IFR. Alternative airfield configurations were prepared from present and proposed airport layout plans. Various configurations were evaluated to assess the benefit of projected improvements.

Air traffic demand levels were derived from *Official Airline Guide* data, historical data, and Capacity Team forecasts. Aircraft volume, mix, and peaking characteristics were considered for each of the three different demand forecast levels (Baseline, Future 1, and Future 2). From this, annual delay estimates were determined based on implementing various improvements. These estimates took into account historic variations in runway configuration, weather, and demand. The annual delay estimates for each configuration were then compared to identify delay reductions resulting from the improvements.

Following the evaluation, the Capacity Team developed a plan of "Recommended Alternatives" for consideration, which is included as a part of Figure 2.

Figures 7 and 8 illustrate the impact of delay at Los Angeles

International Airport. The charts show how delay will continue to grow at a substantial rate as demand increases if there are no improvements made in airfield or airspace capacity, i.e., the "Do Nothing" scenario. Annual delay levels and delay costs are expected to increase from an estimated 41,400 hours and $75.83 million, or about 4 minutes per operation, at the Baseline activity level to 201,000 hours and $422.05 million, or about 15 minutes per operation, by the Future 2 demand level. The chart also shows that the greatest savings in delay costs would be provided by constructing departure pads (staging areas) at the ends of all the runways and restructuring Los Angeles Basin airspace.

Figure 7 Annual Delay Costs — Capacity Enhancement Alternatives

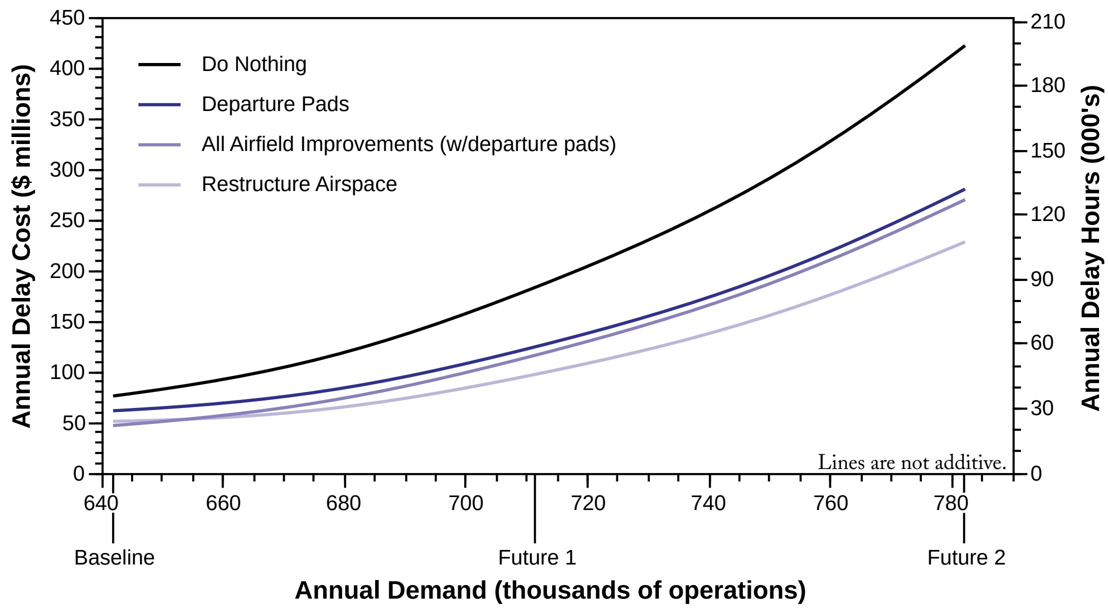
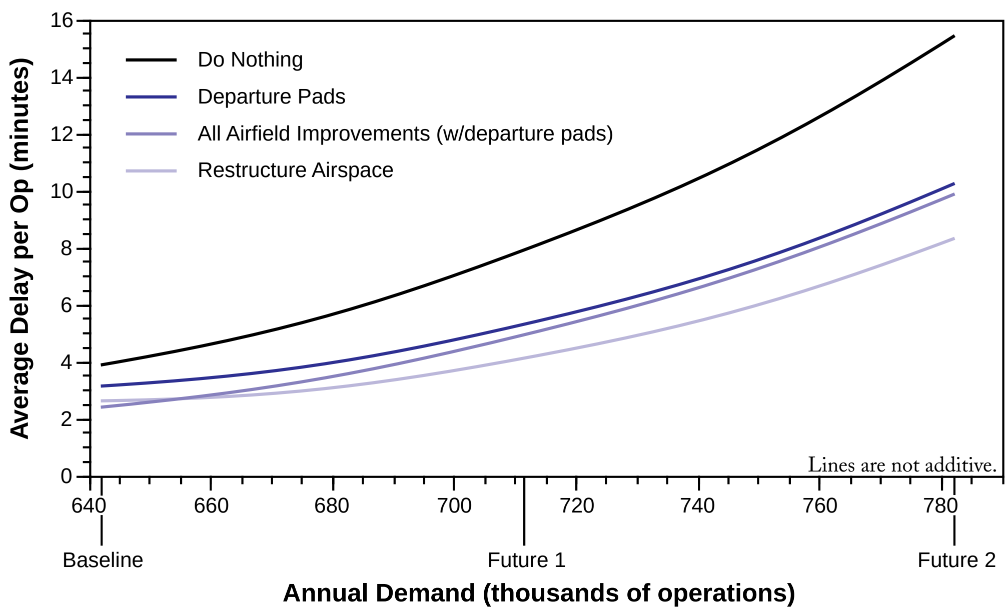


Figure 8 Average Delay Per Operation — Capacity Enhancement Alternatives



Section 2

Capacity Enhancement Alternatives

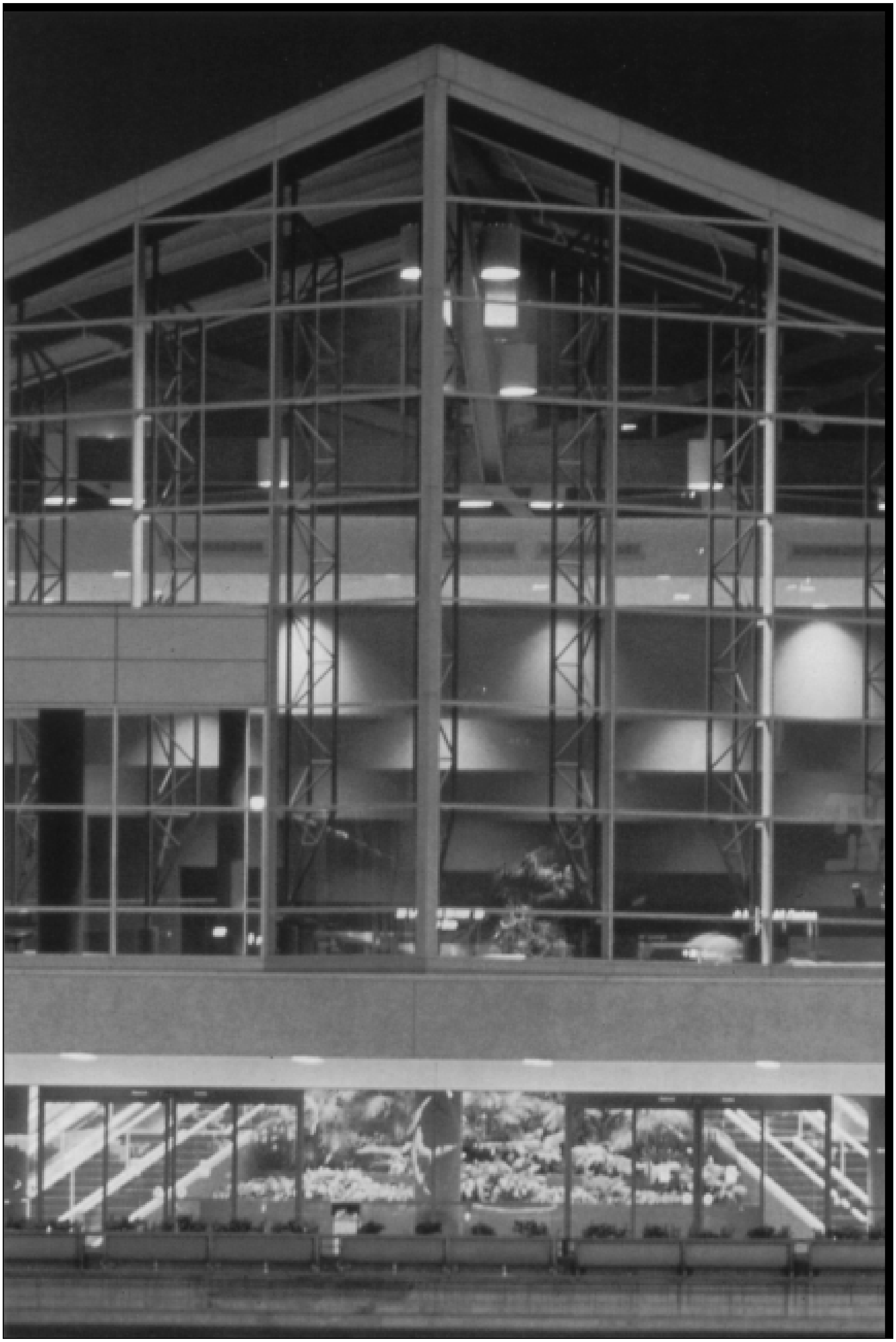


Figure 1 shows the current layout of the airport, plus the airfield improvements considered by the Capacity Team. The LAX Capacity Team selected the capacity enhancement alternatives listed in Figure 2 for evaluation.

Figure 2 presents the recommended action, suggested time frame, and responsible agency for each improvement evaluated for the activity levels Baseline, Future 1, and Future 2, which correspond to annual aircraft operations of 641,751 (projected base level for 1990), 711,092 and 782,056 respectively. The savings benefits of the improvements are not necessarily additive.

These selected alternatives are categorized and discussed under the following headings (the numbers correspond to Figures 1 and 2):

- Airfield Improvements.
- Facilities and Equipment Improvements.
- Procedures Improvements.

Airfield Improvements

1. Construct departure pads (staging areas) at the easterly ends of runways.

Air traffic flow control often dictates that aircraft hold at the runway thresholds before take-off because of departure flow restrictions. Expanding the staging areas at the ends of the runways would improve the ability of departing aircraft to bypass those aircraft waiting for departure clearance.

The airfield improvement under alternative 6, extending Taxiway K to the east, should provide for the sequencing of aircraft for departure on the south-side runways. However, for the north-side runways, there appears to be no space available on the east end to provide for the suggested departure pads without effectively shortening the runways. Additional studies are required to determine the exact locations for both north-side and south-side staging areas.

Annual savings at the current (Baseline) activity level would be 7,692 hours or $14.06 million, and, at Future 2 activity levels, 67,274 hours or $141.23 million.

2. Construct additional gates on the west side of Tom Bradley International Terminal (TBIT).

This project would provide an additional 11 widebody-aircraft gates to accommodate the increase in international demand at LAX. Taxiways 48 and 49 would be moved to the west to make room for this terminal expansion. The eastern most taxiway would not operate as a high-speed taxiway in this proposal since it would be used for access to and from the new gates.

Estimated 1990 project cost is $75.0 million.

3. Construct a new domestic terminal east of Terminal 1.

This project would provide an additional eight gates to accommodate the expected increase in domestic aircraft operations at LAX. The placement of a new terminal in this location would significantly add to taxiway delay due to directional conflicts between aircraft in the taxiways to the east end of the north runways. This alternative is not recommended.

Estimated 1990 project cost is $120 million, including land acquisition.

Additional annual delay costs at the Future 2 activity level would be 6,447 hours or $13.53 million.

4. Construct a new domestic midfield terminal east of Sepulveda Boulevard and a 24-gate international terminal on the west end.

This project would provide an additional 11 gates to accommodate the expected increase in domestic aircraft operations at LAX. This new terminal would be built on an existing maintenance leasehold. A passenger busing operation would be required to support this location. This project would also include a 24-gate international terminal at the west end of the airport as described in alternative 5 below.

Estimated 1990 project cost is $425 million.

Annual savings at the Future 2 activity level would be 2,298 hours or $4.82 million.

5. Construct new passenger gates/terminal at west end of airport.

5a. Construct 24 remote aircraft parking positions (no terminal) for international operations in Future 2.

The lack of sufficient aircraft parking positions results in congestion on the taxiways that interferes with arriving and departing aircraft operations. Under this project, 63 acres of aircraft apron with associated drainage facilities and utilities would be constructed in the area north of World Way West between the proposed Taxiway 75 and Pershing Drive. It would join the east and south edges of the existing Remote Aircraft Parking (Phase 2A) project. This apron would provide a total of 24 widebody-aircraft parking positions for passenger operations and overnight parking.

Estimated 1990 project cost is $36.3 million. Construction is scheduled to begin March 1992, with completion scheduled for January 1993.

Annual savings at the Future 2 activity level would be 1,722 hours or $3.62 million.

5b. Construct 24-gate passenger terminal for domestic and/or international operations.

This project would provide a 2.4 million square foot terminal building, automobile parking facilities, utilities, and 24 gates. This new terminal would be built on the west side of LAX to replace the 24 position remote parking apron described under alternative 5a.

Estimated 1990 project cost is $400 million, not including required access improvements.

If the new terminal were used for both domestic and international operations, annual savings at the Future 1 activity level would be 1,016 hours or $2.0 million, and, at Future 2 activity levels, 8,846 hours or $18.57 million.

If the terminal were used only for international operations, further evaluation would be needed to determine the benefits. This project would likely be combined with the conversion of the Tom Bradley International Terminal to domestic operations.

6. Extend existing Taxiway K to the east.

This two-phased project consists of extending Taxiway K to the east from Taxiway 30 to Taxiway 3 and would include a bridge over Sepulveda Boulevard. Use of double taxiways for departures on runway 25R and 25L would greatly enhance the tower's ability to properly stage aircraft relative to in-trail restrictions.

This extension of Taxiway K, with properly designed tie-ins to the existing Taxiway J, would satisfy the requirements of airfield improvement alternative 1, constructing departure pads (staging areas) at ends of runways, for west traffic on the south complex. These improvements should provide the additional concrete needed to give flow control the ability to re-sequence departures on the south-side runway complex.

Estimated 1990 project cost is $27 million. Construction is scheduled to begin on the first phase in January 1993 and be completed by January 1994. Phase 2 is scheduled for completion in January 1996.

7. Construct high-speed Taxiway 43.

This project calls for the construction of a high-speed taxiway exit for aircraft landing on Runway 25R/25L to the northbound taxiway west of the Tom Bradley International Terminal (TBIT). This new taxiway should reduce runway occupancy times and provide a significant savings in aircraft taxi time by providing a more direct route to the terminal.

The estimated project cost in 1990 dollars is $5.3 million. Construction is scheduled to begin in August 1993 and be completed by November 1993.

Annual savings at the current (Baseline) activity level would be 441 hours or $0.8 million, and, at Future 2 activity levels, 455 hours or $0.96 million.

8. Construct high-speed Taxiway 49U.

This project would provide a high-speed taxiway for aircraft landing on Runway 6R directly to southbound Taxiway 49. This new taxiway could reduce runway occupancy times and provide a savings in aircraft taxi time by providing a more direct route to the terminal.

For nighttime flows, shorter runway occupancy times as a result of high-speed turn offs will not decrease runway delays because sequential arrival separations are much greater than occupancy times. This improvement could decrease aircraft ground travel times and result in a small decrease in departure delays.

Estimated 1990 project cost is $0.8 million.

9. Extend Runway 24R and associated Taxiway 85V.

This project would extend Runway 24R to a planned length of 10,285 feet to increase the takeoff capacity equal to that of Runway 24L. The 1,360-foot runway extension would include drainage facilities, centerline and edge lights, and paved shoulders. The 700-foot taxiway connection (Taxiway 85V) would include edge lights and paved shoulders.

The high-speed turn off, Taxiway 85V, will not decrease runway delays, and most departures use Runway 24L rather than 24R. When Taxiway 75 is completed, arrivals on the north side that will use terminal gates on the south side will have an added incentive to use high-speed exit 75 rather than any exit further down the runway.

Estimated 1990 project cost is $3.9 million.

10. Extend Taxiways 48 and 49 to Taxiway F.

This improvement will provide additional entrance and exit routes to and from the south-side cargo area. Congestion at the intersection of Taxiways 49 and K will be relieved. Conflicts of opposing traffic on the single south-side Taxiway F will also be relieved.

Estimated 1990 project cost is $4.3 million. Construction is scheduled to begin June 1995 and be completed by November 1995.

11. Construct high-speed taxiway off Runway 7L and 7R.

This project would provide a high-speed taxiway from Runway 7L and 7R to Taxiway F on the south side of the airfield. The benefits from this improvement would be limited to nighttime operations. It would not decrease runway delays but would decrease aircraft travel times.

Estimated 1990 project cost is $5.4 million.

Facilities and Equipment Improvements

12. Construct new Airport Traffic Control Tower (ATCT).

As a result of airport expansion during the 28-year life of the existing Airport Traffic Control Tower, tower visibility of the north/south taxiway system has been lost. This system is the only route connecting the north and south airport complexes. Construction of a new, relocated tower would provide for more efficient use of the airport.

The estimated project cost in 1990 dollars is $15.0 million.

13. Upgrade ILS on Runway 25L to Category III.

Upgrading ILS on Runway 25L to Category III would provide complete all-weather capabilities. This would reduce visibility minimums and thereby maintain capacity during Instrument Meteorological Conditions (IMC).

The estimated cost in 1990 dollars is $1.3 million.

The delay savings at the current (Baseline) activity level would be 1,053 hours or $1.92 million, and, at the Future 2 activity levels, 619 hours or $1.3 million. These delay savings are based on 10 CAT III days per year, 3 hours per day.

Procedures Improvements

14. Taxi aircraft versus tow from remote parking areas to gates.

This project considered taxiing 30 percent of overnight aircraft from gate positions to the remote parking area south of Runway 24l versus towing the aircraft. The difference in taxi speeds versus towing speeds was 15 knots versus five knots.

The annual savings for taxiing aircraft at the current (Baseline) activity level would be 6,060 hours or $11.08 million, and, at Future 1 activity levels, 1,747 hours or $3.43 million. Future 1 benefits are lower than Baseline because N/S Taxiway 75 is assumed to be operational by Future 1.

15. Restructure terminal and Los Angeles Basin airspace.

The Capacity Team highly recommends a complete airspace capacity design analysis project for all of the Los Angeles Basin airspace that interconnects with LAX. This analysis should include concepts of airspace restructuring that offer the potential for improving arrival and departure air route capacity in conjunction with airport improvements. New technology and operating concepts need to be reviewed in an effort to improve flow-control procedures and reduce or eliminate miles-in-trail restrictions that are beyond optimal aircraft spacing. The goal would be to ensure sufficient airspace capacity to fully utilize the airport's surface capacity.

The current and potential cost of airspace restrictions, beyond optimal aircraft spacing and, therefore, the potential annual savings at the current (Baseline) activity level would be 5,809 hours or $10.62 million, and, at Future 2 activity levels, 25,022 hours or $52.53 million.

Section 3

Summary of Technical Studies

Overview

The Los Angeles International Airport Capacity Team analyzed the operation of the existing airfield and the potential benefits of the proposed improvements in terms of airfield capacity, airfield demand, and average aircraft delays.

The Capacity Team used the Runway Delay Simulation Model (RDSIM) and the Airfield Delay Simulation Model (ADSIM) to determine aircraft delays throughout the day. Delays were calculated for current and future conditions.

Daily operations corresponding to an average day in the peak month were used for each of the forecast periods. Daily delays were annualized to measure the potential economic benefits of the proposed improvements. The annualized delays provide a basis for comparing the benefits of the proposed changes.

The fleet mix at Los Angeles International Airport (LAX) has an average direct operating cost of $2,100 per hour for Future 2. This figure represents the costs for operating the aircraft and includes such items as fuel, maintenance, and crew costs, but it does not consider lost passenger time, disruption to airline schedules, or any other intangible factors.

The cost of a particular improvement is measured against its annual delay savings. This comparison indicates which improvement will be the most effective. For expected increases in demand, a combination of improvements can be implemented to allow airfield capacity to increase, while aircraft delays are minimized, at a cost that can be sustained by the airport and the airline community.

The LAX Capacity Team evaluated the efficiency of the existing airfield and the proposed future configuration. Figure 9 lists airfield weather conditions.

Figure 9 Airfield Weather — West Flow

Category	Ceiling/Visibility	Occurrence (%)
VFR 1	1,000 feet or above / 3 SM or above	90.4
VFR 2	Between 999 and 800 feet / 3 SM or above	2.0
IFR	Below 800 feet / below 3 SM	7.6

VFR — Visual Flight Rules
IFR — Instrument Flight Rules
SM — Statute Miles

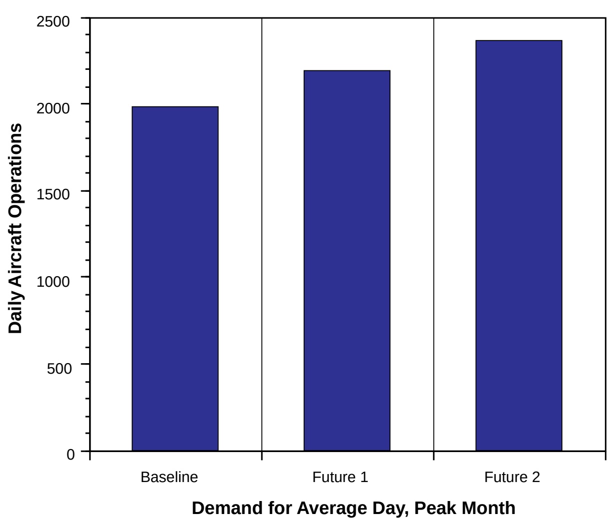
Airfield Capacity

The LAX Capacity Team defined airfield capacity to be the maximum number of aircraft operations (landings or take-offs) that can take place in a given time. They recognized that airfield capacity is a very complex problem that cannot be represented by a constant value, but varies as conditions change. In its analysis, the Capacity Team considered the following conditions.

- Level of delay
- Airspace constraints
- Ceiling and visibility conditions
- Runway layout and use
- Aircraft mix
- Percent arrival versus departure demand

Figure 10 illustrates the average-day, peak-month arrival and departure demand levels for LAX for each of the three annual activity levels used in the study, Baseline, Future 1, and Future 2.

Figure 10 Airfield Demand Levels — Aircraft Operations and Average Day of Peak Month



Time Period	Ops per Year	Ops per Day	Peak Hour Ops
Baseline	641,751	1,987	139
Future 1	711,092	2,193	147
Future 2	782,056	2,367	159

Figure 11 describes the airport capacity for LAX with a series of curves depicting delay as a function of flow rate. The curves were developed for the existing baseline airport configuration, with four parallel runways, under instrument flight rules (IFR) and visual flight rules (VFR) conditions, with a 50/50 split of arrivals and departures. The capacity mode of the Runway Delay Simulation Model (RDSIM), which is described in Appendix B, was used in developing these curves. They are based on the assumption that arrival and departure demand is randomly distributed within the hour. Other patterns of demand can alter the demand/delay relationship.

The curves in Figure 11 illustrate the relationship between flow, the number of operations per hour, and the average delay per aircraft. They show that, as the number of aircraft operations per hour increases, the average delay per operation increases exponentially.

Figure 12 illustrates the hourly profile of daily demand for the Baseline activity level of 641,751 aircraft operations per year. It also includes a curve that depicts the profile of daily operations for the Future 2 activity level of 782,056 aircraft operations per year.

The VFR curve represents the operation of the airfield under optimum FAA procedures. The IFR curve in Figure 11 shows the capacity under IFR which occurs during adverse weather conditions, only about 7.6% of the year. The actual current operating capacity of the airport is somewhere in between these two curves. The IFR curve indicates that aircraft delays will begin to escalate rapidly as hourly demand exceeds 90 to 100 operations per hour under IFR conditions. Figure 12 shows that hourly demand exceeds 90 to 100 operations during much of the day at Baseline demand levels and more so at Future 2. Therefore, substantial delays are likely during poor weather conditions. It is apparent that the current operating capacity is exceeded at the present time during peak hours based on observed delays.

Figure 11 Flow Rate Versus Average Delay

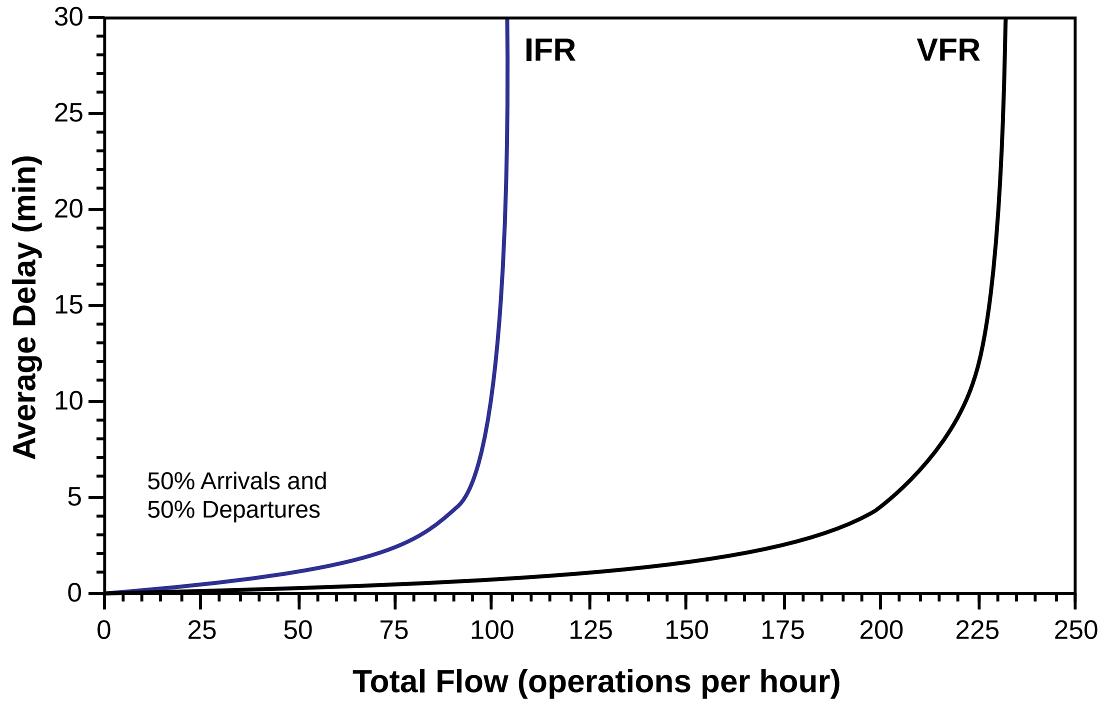
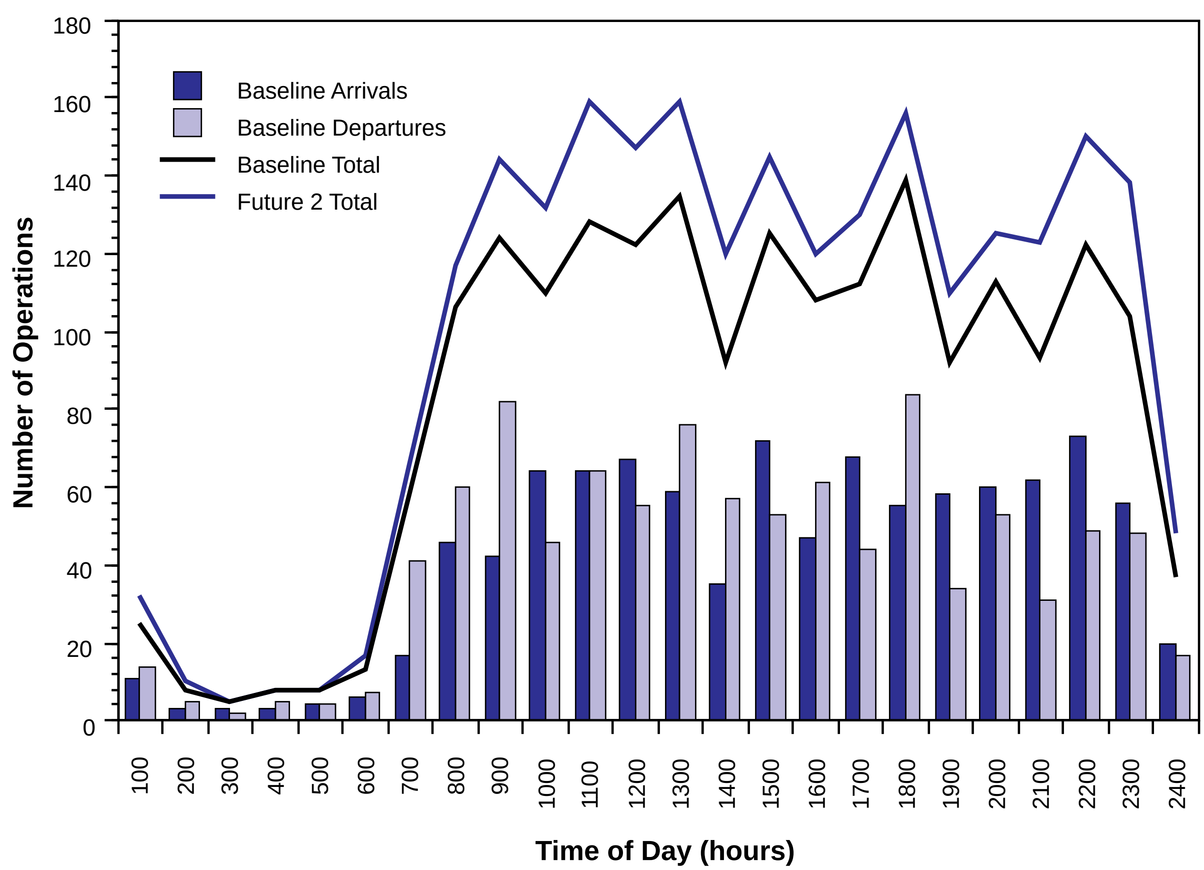


Figure 12 Profile of Daily Demand — Hourly Distribution



Aircraft Delays

Aircraft delay is defined as the time above the unimpeded travel time for an aircraft to move from its origin to its destination. Aircraft delay results from interference from other aircraft in the system competing for the use of the same facilities.

The major factors influencing aircraft delays are:

- Weather
- Airfield and ATC System Demand
- Airfield physical characteristics
- Air traffic control procedures
- Aircraft operational characteristics

Aircraft delays were derived by use of the Airfield Delay Simulation Model (ADSIM) and the Runway Delay Simulation Model (RDSIM). A description of these models is included in Appendix B. The results of the simulation analysis were then appropriately weighted and annualized to develop annual costs.

Annual delay costs, expressed in millions of dollars and thousands of hours for various demand levels, are shown in Figure 13. This figure presents comparisons between the "Do Nothing" and the capacity enhancement alternatives. This figure also identifies the benefits that would result from implementing the individual alternatives.

Figure 14 illustrates the average delay in minutes per aircraft operation for the three demand levels, Baseline, Future 1, and Future 2. If there are no improvements made in airfield capacity, the average delay per operation of about 4 minutes in Baseline will increase to over 15 minutes per operation by Future 2. Even if all the recommended improvements are implemented, the average delay per operation will increase from its present level of 4 minutes per operation to 10 minutes per operation at Future 2 activity levels.

Under the "Do Nothing" situation, if there are no improvements made in airfield capacity, the annual delay cost would continue to increase as follows:

	Annual Delay Costs	
	Hours	**Millions of $**
Baseline	41,492	$75.83
Future 1	93,475	$183.57
Future 2	201,034	$422.05

It should be noted that the implementation of all the recommended improvements would not eliminate the delay in Future 2. In fact, annual delay would still increase from the baseline level of 41,000 hours to 109,000 hours in Future 2. It is, therefore, imperative that other airports be developed within the region to avoid severe constraints on air traffic growth.

Figure 13 Annual Delay Costs — Capacity Enhancement Alternatives

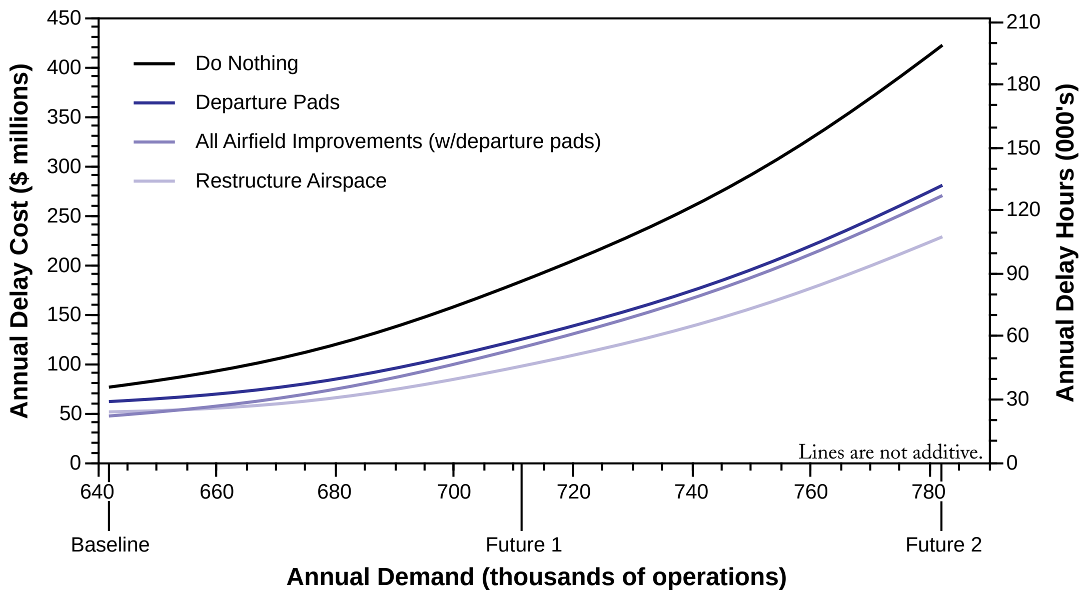
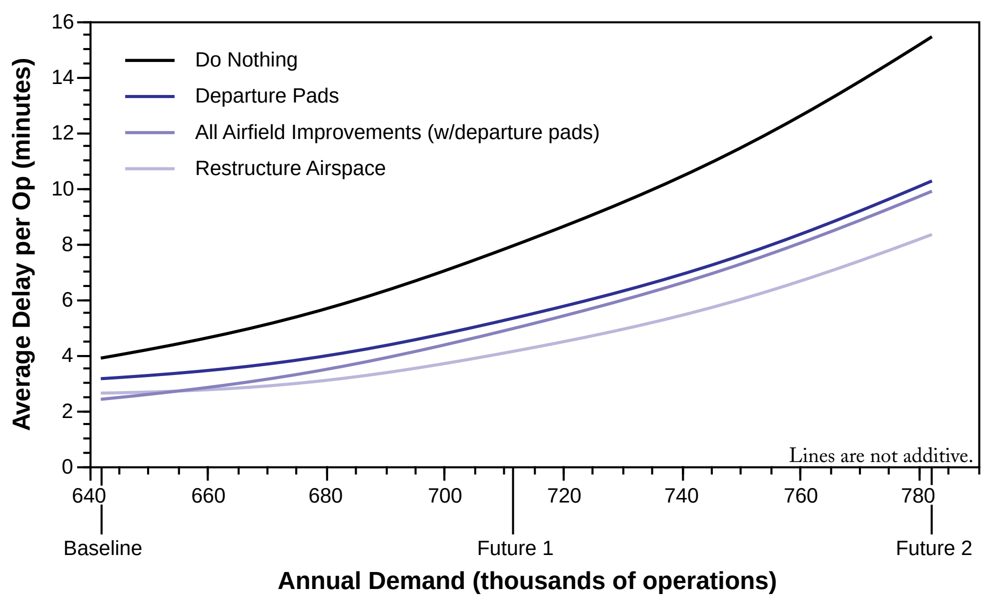


Figure 14 Average Delay Per Operation — Capacity Enhancement Alternatives




PAN AM
Clipper Ocean Spray

Appendix A

Design Team Participants

Federal Aviation Administration Members

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Appendix B

Computer Models and Methodology

The LAX Capacity Team studied the effects of various improvements proposed to reduce delay and enhance capacity. The options were evaluated considering the anticipated increase in demand. The analysis was performed using several computer modeling techniques. A brief description of the models and the methodology employed follows.

Computer Models

Airfield Delay Simulation Model (ADSIM)

This is a fast-time, discrete event model that employs stochastic processes and Monte Carlo sampling techniques. It describes significant movements of aircraft on the airport and the effects of delay in the adjacent airspace. The model was validated in 1978 at Chicago O'Hare International Airport against actual flow rates and delay data. It was calibrated for this study against field data collected at LAX to insure that the model was site specific.

Inputs for the simulation model were derived from empirical field data. The model replicated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability, which occures on a daily basis in actual airport operations. The results were averaged to produce output statistics. Total and hourly aircraft delays, travel times, and flow rates for the airport and for the individual runways were calculated.

Runway Delay Simulation Model (RDSIM)

RDSIM is a short version of the ADSIM model that simulates only the runways and runway exits. Two versions of the model exist. The first version ignores the taxiway and gate complexes for a user-specified daily traffic demand and is used to calculate daily demand statistics. In this mode, the model replicated each experiment forty times, using Monte Carlo sampling techniques to introduce daily variability of results, which were averaged to produce output statistics. The second version also simulates the runway and runway exits only, but it creates its own demand using randomly assigned arrival and departure times. The demand created is based upon user-specified parameters. This form of the model is suitable for capacity analysis.

For a given demand, the model calculates the hourly flow rate and average delay per aircraft during the full period of airport operations. Using the same aircraft mix, computer specialists simulated different demand levels for each run to generate demand versus delay relationships.

Methodology

Model simulations included present and future air traffic control procedures, various airfield improvements, and traffic demands for different times. To assess the benefits of proposed airfield improvements, the FAA used different airfield configurations derived from present and projected airport layouts. The projected implementation time for air traffic control procedures and system improvements determined the aircraft separations used for IFR and VFR weather simulations.

For the delay analysis, agency specialists developed traffic demands based on the *Official Airline Guide*, historical data, and various forecasts. Aircraft volume, mix and peaking characteristics were developed for three demand periods (Baseline, Future 1, and Future 2). The estimated annual delays for the proposed improvement options were calculated from the experimental results. These estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data.

The potential delay reductions for each improvement were assessed by comparing the annual delay estimates.

The RDSIM model, in its capacity mode, was used to perform the capacity analysis for LAX.

Appendix C

Glossary

ADSIM	Airfield Delay Simulation Model
AOPA	Aircraft Owners and Pilots Association
ATA	Air Transport Association of America
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
AWP	FAA Western Pacific Region
DOA	Los Angeles Department of Airports
FAA	Federal Aviation Administration
FAR Part 150	Federal Aviation Regulation on Airport Noise Compatibility Studies
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
LAX	Los Angeles International Airport
RDSIM	Runway Delay Simulation Model
RVR	Runway Visual Range
SM	statute miles
TBIT	Tom Bradley International Terminal
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions

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Notes

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